MODULAR BUS BODY ASSEMBLY

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field:

[0002] The invention relates to motor vehicle body assembly and more particularly to a system and method of bus body assembly allowing differentiation in configuration using standard body sections.

[0003] 2. Description of the Problem:

[0004] Operators of coaches and busses, particularly school busses, often demand specialized body configurations in terms of the location for exit locations and types, body length, engine location (e.g. front engine, rear engine and conventional) and roof height. The current practice for bus construction provides for assembly of a body frame on top of a chassis and then applying a skin over the body frame. This process requires first building a floor structure as a foundation. Then roof bows, stringers and drip rails are raised on the floor assembly to make the body's skeleton. Next, outer and inner sheet metal panels are applied to the skeleton enclosing the body. Building vehicles in this manner to meet differing customer requirements has demanded custom layout, specification of and cutting body elements to fit the custom requirements. All of this variation minimizes the opportunity for use of repetitive construction techniques and makes automation of assembly difficult.

[0005] Automated assembly is made easier by application of a modular manufacturing strategy. Modular manufacturing strategies typically deconstruct a product line (including variations) into discrete sub-assemblies (modules), usually located with some degree of arbitrariness. When the modules are combined in various numbers and arrangements multiple product configurations are possible. This type of sub-assembly typically does not exhibit what is termed "functional cohesion". An example of a sub-assembly module for a motor vehicle is the vehicle engine. An engine is part of a vehicle drive train and is regarded as a standard module in automotive and truck design. It is not

a functionally cohesive module, however, because it cannot perform its intended function without a compatible cooling system, fuel system and transmission. When the engine is changed all of the associated drive train sub-assemblies are subject to change to accommodate the change of engine. A functionally cohesive module tolerates changes in other modules but still performs its function.

[0006] Where and how demarcations are made in defining sub-assembly units can control how functionally cohesive a sub-assembly is. A bus body may be divided into various kinds of sub-assemblies and remain "modular". For example, a possible modular bus body might have floor, front end, side, rear end and roof modules. To accommodate customer requests for busses of different lengths the side, roof and floor modules would have to provided in different lengths. The sub-assemblies would lack cohesion. As a consequence, synchronization would be required in delivery of the parts for assembly, adding complexity to the manufacturing process.

SUMMARY OF THE INVENTION

[0007] According to the invention there is provided a bus body comprising a combination of longitudinal body sections. The longitudinal body sections are provided in a plurality of types from which the combination is drawn. A combination may include some or all of the types of body sections, and may include more than one example of a particular type of longitudinal body section. The types of longitudinal body sections include a section type adapted to fit on a chassis over a group of wheels, a section type including an auxiliary side door, a section type including a passenger boarding well and a section type having parallel fixed side walls. The section type having parallel fixed side walls is provided in at least two standard lengths. The types of longitudinal body sections are also provided in first and second predetermined heights. End caps and forward assemblies for closing the opposite longitudinal ends of the bus body are also provided.

[0008] Additional effects, features and advantages will be apparent in the written description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

[0010] **Fig. 1** is a perspective view of a chassis for a truck or bus.

[0011] **Fig. 2** is a side elevation of a front engine school bus.

[0012] **Figs. 3A** through 3G are perspective views of each of a set of longitudinally intermediate, modular, standardized body sections used for constructing a school bus body.

[0013] **Fig. 4** is a perspective view of an end cap for a school bus body.

[0014] **Figs. 5A** through **5F** are perspective views of each of a set of front end assemblies for a school bus body.

[0015] **Fig. 6A** is a perspective view of the mounting of an intermediate, modular standardized body section on a bus chassis.

[0016] **Fig. 6B** is a cross sectional view of adjacent rib bows.

[0017] **Fig. 7** is a cross sectional view illustrating floor to body side mating of the intermediate, modular, standardized sections.

[0018] **Fig. 8** is a perspective view illustrating construction of floors of sections.

[0019] **Fig. 9** is a perspective view of construction of a body side.

[0020] **Figs. 10A-B** are bottom plan views of possible bus body configurations.

[0021] **Fig. 11** is detailed view of a joint between two floor or wall panel segments.

[0022] **Fig. 12** is an illustration of manufacturing flow for assembling vehicles from modular sections.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Referring now to **Fig. 1** a vehicle chassis **10** is illustrated. The foundational component of chassis **10** is a box frame **12**. Box frame **12** provides connection points for suspension elements which position rear axle **18** and front axle **19**. Rear wheels **20** and front wheels **22** are mounted on axles **18** and **19,** respectively. Box frame **12** carries an engine **14** and dashpanel **16** and provides a base for the construction of a body in accordance with the invention as taught below. Vehicle chassis **10** is configured for a conventional bus, that is one with the engine **14** mounted forward of dashpanel **16** on the chassis and the body being built behind the dashpanel. However, the invention is equally applicable to rear engine and front engine busses. Front engine busses have a flush front end with the engine being mounted on the frame below the floor of the passenger cabin.

[0024] **Fig. 2** illustrates in side elevation a front engine school bus **24**. Front engine bus **24** incorporates an engine mounted to the vehicle chassis under the vehicle body floor at the vehicle's forward end. The bus body **25** rests on a chassis supported by front wheels **30** and rear wheels **32**. The interior of body **25** is normally accessed by a passenger door **36** located toward the front of the vehicle, and may be accessed through auxiliary doors at the rear of the vehicle (not shown) or the side of the vehicle. An auxiliary door **38** is illustrated in the side of front engine bus **24**. Exclusive of the passenger door **36** and the auxiliary door **38**, the length of body **25** along both sides of the vehicle, is lined by standard sized windows **34** toward the top of the passenger cabin.

[0025] Body **25** is illustrated as comprising a plurality of section modules **40, 42, 44, 46,** and **48** which are arrayed lengthwise on the bus chassis. Modules **40** and **44** are repeated at different

locations. The modules **40**, **42**, **44**, **46**, and **48** incorporate body elements, which are repeated from vehicle to vehicle, but which are not always located at the same longitudinal position on the bus, such as the passenger door **36** or a side auxiliary door **38**. In body **25** passenger door **36** is incorporated in a longitudinal body module **42** positioned at the front end of bus body **25**. In a front engine bus **24** the passenger cabin is disposed over both sets of wheels, namely front wheels **30** and rear wheels **32**. Identical over wheel modules **40** may be used at each location, each module being long enough to incorporate three side windows **34** on each side. Three sections comprising uninterrupted side walls and windows **34** are designated as modules **44**, **48**. Two sections are provided by modules **44**, one immediately behind front wheels **30** and the second behind rear wheels **32**. A module **44** has two windows **34** to a side, and module **48**, located between the forward module **44** and the auxiliary door module **46**, is half again as long as one of modules **44** and has three windows **34** to a side.

[0026] The illustrated arrangement or combination of modules for bus **24** in **Fig. 2** is by no means the only one possible. Auxiliary door module **46** and passenger door module **42** are both the same length from front to back as one of modules **44**, and the positions of these modules are very flexible. For example, passenger door module **42** can be placed at the back of the bus and the iteration of module **44** located there moved to the front of the bus in place of the passenger door module **42**. The modules **44**, **46** and **48** located between front wheels **30** and rear wheels **32** can be rearranged as desired. Only the over wheel modules **40** are practically limited to locations centered over the axes of rotation of the front and rear wheels. However, for conventional busses only one over wheel module, for the portion of the chassis over the rear wheels **32**, is used. The number or combination of modules used is varied depending upon the chassis' length. All of modules **40**, **42**, **44**, **46** and **48** may be prefabricated in batches and the combination used for a particular bus selected from pools of modules.

[0027] Bus body **25** is closed at opposite longitudinal ends by a front end section **26** and an end cap **28**. Front ends and end caps are also interchangeable parts with other busses of the same type and height.

[0028] Referring now to **Figs. 3A-G**, individual module types are illustrated. Individual types of body section modules include certain generic features, e.g. frames **50** for windows **34** and roof bows **52**. Five basic types of body section modules are provided, with each type coming in one of two heights. The body section modules may have either a 78" high roof or a 74" high roof. The difference occurs in height differences between windows as exemplified between a body section module type **44** which has a window height of H, and body section module type **144**, which has a window frame **50** height of H-4. Modules typically come in one of two lengths, determined by the number of roof bows **52** they have. The spacing between roof bows **52** determines the standard lengths for the various types of longitudinally intermediate body modules. Bows **52** are spaced by 27" and a module includes either three bows **52** or four bows so that the length of a module is about 2 bow gaps (about 54") or three bow gaps (about 81"), although other gap lengths are possible. Some of the modules are illustrated with exposed roof bows **252**, while other sub-assemblies are completed with roof **152**.

[0029] The five basic types of body section modules include a short main body or short seating bay module **44** of two bow **52** gaps, characterized by side walls **54** which are uninterrupted from front to back. Similar to short main body module **44** is long main body or long seating bay module **48** which has four bows **52** for a length of three bow gaps and uninterrupted main side walls **154**. A floor **60** forms the bottom of short main body section module **44** and a longer floor **160** provides the base for long main body module section **48**. The three remaining body section modules serve more specialized functions, or, in the case of an over wheel body section module **40**, are adapted to fit at particular points of the chassis. Over wheel body module **40** includes four roof bows **52** giving the unit approximately a three gap length. Over wheel body modules **40** are limited to positions over a vehicle's wheels, which means two modules are used for rear and front engine buses and one module is used over the rear wheels on busses with conventionally located engines. Over wheel body module **40** incorporates a floor **64** having wheel wells **66** on opposite sides of the module. Two sections relate to ingress and egress from a bus including a passenger door body module section **42**, which includes a door well **58** in the floor **62** and a full height passenger door **36**, allowing easy access from street level, and an auxiliary door body module **46**, which incorporates a partial height door **38** with a lower edge substantially level with floor **60** of the module. The specialized modules

come in one of two body heights, however, only one height is shown for the specialized section modules.

[0030] In addition to the body section modules, which are placed intermediate the front and rear ends of a bus, there are also end cap assemblies **28** and front end assemblies. These components are preexisting modules and come in one basic type (in two heights) for the rear end of the vehicle, shown in **Fig. 4** and as three types (again in two heights) for the front of the vehicle. These include, high roof and low roof conventional front ends **226** and **326**, high and low roof front engine assemblies **26** and **126** and high and low roof rear engine front end assemblies **426** and **526**, shown in **Figs. 5A-5F**.

[0031] The several body section modules illustrated in **Figs. 3, 4** and **5** exhibit a high degree of functional cohesion. A standard body section of **Figs. 3A-D** provides a bay for occupant seating, the module of **Fig. 3E** provides an exit door and exit aisle and all of the modules may be applied to busses of virtually any practical length. Modules function for their intended purpose regardless of its adjacent module, so that a plurality of modules are required for a complete bus, positioning of one module in a particular position does not entail positioning of a specialized module adjacent to it. Changes to adjacent modules does not effect the functionality of a module. This in turn allows for producing a wide variety of bus-body configurations with only a handful of functionally cohesive modules. Bus body configuration may be specified by the selection of modules and assembly these modules do not have to be sequentially line set. The present invention allows the asynchronous manufacture of bus body modules that can than be buffered (i.e. stored) until demanded on the assembly line.

[0032] **Fig. 6A** illustrates positioning of a representative intermediate body section module, here a partial main body section module **544**, on left side and right side frame rails **70** and **72** of a vehicle chassis. Floor **60** is attached to frame rails **70** and **72** by fasteners or spot welding. Body module **544** rests latitudinally centered over frame rails **70, 72**, with floor **60** overlapping the rails to both sides. A side skirt **74** extending below the side walls **54** of the main body of body module **544** thereby hiding frame rail **70** from view from the side. Side skirt **74** is preferably provided as an

integral part of the module.

[0033] Fig. **6B** is a cross section taken along a pair of adjacent roof bows **52**, brought into proximity to one another when two intermediate section modules are positioned next to one another. Roof bows **52** are C-channels, with the channel face turned downwardly to provide a smooth upper surface for the positioning of roof sections **76**. As illustrated, modules are assembled with roof bows **52** exposed and a roof applied after the rest of the external body is constructed. Alternatively, the modules can be sub-assembled with a roof skin. Where this is done, a standard module incorporating a roof hatch may be provided, perhaps included in one of the straight wall modules.

[0034] Referring to **Fig. 7** possible construction details of an intermediate body module, viewed in cross section at the base of the juncture between wall and floor, are shown. The detail joint designs are illustrative only and numerous other types of joints are possible. A floor panel **80** provides a foundation, along an edge of which is disposed a seat rail with integral side skirt **88**. Seat rail **88** has an inside, upward oriented flange against which is nestled the base of a side wall section (roll form shape) **84**, an intermediate, horizontal section which rests on the floor, and an outside, downward oriented flange which provides a skirt **74**. Skirt **74** extends well below the level of floor section (roll form shape) **80** and accordingly is braced by gussets **86**, one of which is shown to be fitted between the underside of the floor section **80** and skirt **74**. Floor section **80** are preferably spot welded to seat rail **88**. Side wall/body side **84** is preferably attached to rail **88** by blind rivets, weld nuts, or studs. Gusset **86** is preferably spot welded to floor section **80** and skirt **74** of rail **88**.

[0035] **Figs. 8** and **9** depict assembly of intermediate module floors and side walls from roll form shaped panels **80/84**, which are essentially identical to one another in shape, although not in dimensions, hole and attachment point patterns. Roll form shaped panels **80/84** are essentially flat, rectangular panels, with one pair of opposite edges turned under and inwardly to from C-channels **90** along a pair of edges of the panels. The outside face of C-channels **90** perpendicular to the principal plane of the panels are brought adjacent one another as illustrated in **Fig. 11** and joints are formed by spot welding or self pierce riveting to adjacent C-channels **90** and to the frame rails **70** and **72**. No bows are required for the body side walls or floor due to the strength provided by the cross sectional

shape of the panels.

[0036] As described above, numerous combinations of intermediate section modules are possible. **Figs. 10A** and **B** illustrate possible configurations for a rear engine bus **102** and a conventional bus **104,** respectively. For both busses the front and rear are marked "F" and "R", respectively. For rear engine bus **102** the forward most intermediate section is a passenger door module **42**. Moving to the rear module **42** is followed by the first of two over wheel sections **40**, two successive long main body modules **48**, the second over wheel module **40**, and two short main body modules **44**. Conventional bus **104** has, moving from front to rear an auxiliary door section **46**, two successive short main body sections **44**, a long main module **48**, an overwheel module **40**, another short main body section **44** and, at the rear of bus **102**, a passenger door section **42**.

[0037] **Fig. 12** illustrates a manufacturing flow process **200** for assembly of a bus body utilizing body modules. Modules are assembled in fabrication cells dedicated to the particular module types. Historical data can be used to predict the number of each modules to make. The sub-assembly types can include a wheelwell module fabrication cell **202**, a straight wall short length module fabrication cell **204**, a straight wall long length module fabrication cell **206**, a front end module fabrication cell **208**, a rear end module fabrication module cell **210**, an auxiliary door module fabrication cell **207** and a passenger door module fabrication cell **209**. Modules are not typically dedicated to a particular bus and can be held until needed in a storage area **212**. Once a plan **215** for a bus is received on the assembly floor, selection **214** of modules delivers modules to a bus body assembly area **216**. From body assembly the bus body moves to a roof assembly area **218**, if required.

[0038] The invention provides for configuring custom busses from a minimal number of standardized modules.

[0039] While the invention is shown in only one of its forms, it is not thus limited but is susceptible to various changes and modifications without departing from the spirit and scope of the invention.